Massachusetts Institute of Technology
C. S. Draper Laboratory
Cambridge, Massachusetts

LUMINARY Memo #141

To: Distribution
From: L. Berman
Date: 10 March 1970
Subject: Replacement of LOGSUB in Luminary

The Ascent Guidance Equations in LUMINARY require the generation of a logarithm, specifically log $(1 - Tgo/T_{Bup})$. To do this, a 7th order polynomial is used, with POLY doing the actual work. The setup for POLY is done in a section called LOGSUB.

It turns out that LOGSUB is not used anywhere else in LUMINARY. Since the accuracy of a 7th order polynomial is not needed in the guidance, it makes sense to replace it with a simpler procedure.

$$\log (1 - Tgo/T_{Bup}) = - \frac{Tgo}{T_{Bup}} - 1/2(\frac{Tgo}{T_{Bup}})^2 - 1/3 (\frac{Tgo}{T_{Bup}})^3 ---$$

For the kind of vehicles we are familiar with, Tgo/T_{Bup} is normally not larger than about .5 (anything significantly larger means you have very little payload). Thus a short series should work adequately. With a little computation I have found

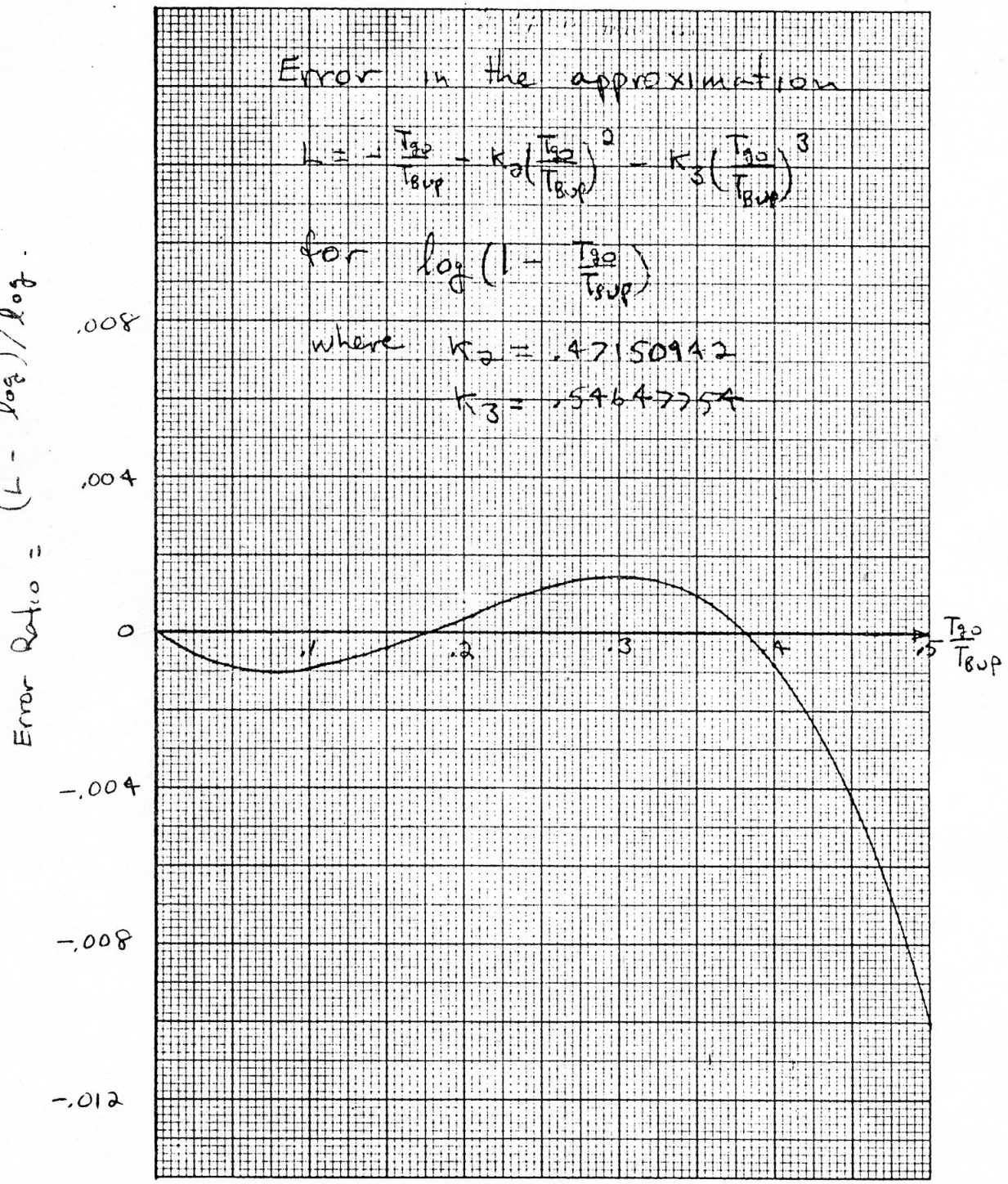
$$L = -\frac{Tgo}{T_{Bup}} - .47150942 (\frac{Tgo}{T_{Bup}})^2 - .54647754 (\frac{Tgo}{T_{Bup}})^3$$

to look reasonable. Its error, (L - log)/log, is shown on the attached figure. Maximum error for $Tgo/T_{Bup} \leq .5$ is about 1%, and for a LM-type vehicle, the equivalent error in Tgo is reduced to .01 sec by the time Tgo is reduced to 15 sec.

old		new	
DLOAD	DSU	DLOAD	DDV
	TBUP		TGO
	TGO		TBUP

old		new	
DDV	CALL	EXIT	
	TBUP	TC	POLY
	LOGSUB	DEC	2
SL	PUSH	2DEC	0
	5	2DEC	-1.0
	(8 reg)		
	+	2DEC	-0.47150942
	LOGSUB (38 reg)	2DEC	-0.54647754
	= 46 reg	TC	INTPRET
		PUSH	
		16 reg	

A saving of 30 registers is seen (also some time saving), all in BANK 30, so that coding changes would be simple.


Error in the approximation
$L = -\frac{T_{go}}{T_{BUP}} - K_2\left(\frac{T_{go}}{T_{BUP}}\right)^2 - K_3\left(\frac{T_{go}}{T_{BUP}}\right)^3$
for $\log\left(1 - \frac{T_{go}}{T_{BUP}}\right)$
where $K_2 = .4715092$
$K_3 = .5464754$
Error Ratio = $(L - \log)/\log$.
.008
.004
0
-.004
-.008
-.012
.1
.2
.3
.4
.5
$\frac{T_{go}}{T_{BUP}}$